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Climate Change, the Economy, and Conflict

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Abstract

Purpose of Review The relationship between climate change and violent conflict has been the subject of intense academic as well as policy debate over the past few decades. Adverse economic conditions constitute an important channel linking the two phenomena. Here, I review the theoretical arguments and recent empirical evidence connecting climate-driven adverse economic conditions to conflict.

Recent Findings Climate-induced adverse economic conditions could lead to conflict by lowering the opportunity cost of violence, weakening state capacity, and exacerbating political and economic inequalities/grievances. The empirical literature does not provide robust evidence for a "direct" climate-economy-conflict relationship.

Summary Recent empirical research offers considerable suggestive evidence that climate-driven economic downturns lead to conflict in agriculture-dependent regions and in combination and interaction with other socioeconomic and political factors. Future research should further examine the context(s) in which climate-induced adverse economic conditions led to conflict, and also identify and test the precise empirical implications of the theoretical mechanisms through which these adverse economic conditions lead to conflict using disaggregated data and appropriate estimation procedures.

Keywords Climate change · Climate variability · Economic and agricultural output · Food prices · Conflict

This article is part of the Topical Collection on *Climate Change and Conflicts*

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Introduction

Global climate change is expected to have a far-reaching impact on ecosystems and humans alike. A rapidly growing body of research suggests that climate variability, in particular extreme fluctuations in rainfall and temperature, affects human conflict.[1] One important channel which links climate change to political violence and conflict[2] is economic disruption.[3]

Climate variability, by reducing economic output and raising food prices, might increase the risk of conflict especially in

[1] Climate change refers to a statistically significant variation in either the mean state of the climate or its variability that persists for an extended period of time (typically decades or longer), e.g., temperature increase and sea level rise. Climate variability, on the other hand, is defined as variations in the mean state and other statistics of the climate on all temporal and spatial scales, beyond individual weather events ([63], 188–189). While climate change and climate variability are different analytic constructs, they are still likely to have common effects on conflict. For example, studying the effects of a persistent period of high temperature could yield imperfect yet useful insights into the effects of global warming. In addition, since reliable data on economic and political variables are only available for the past few decades, especially for countries that have experienced civil conflict (e.g., sub-Saharan countries), it is quite difficult, if not impossible, to examine the effects of climate change on conflict in a rigorous quantitative manner. In this review, I use the terms climate, climate variability, and climatic conditions to refer to climatic variables: temperature, precipitation/rainfall and extreme weather events.

[2] Following the trend in the literature, the focus of this review is on intrastate (domestic) conflict as opposed to interstate conflict and includes all types of conflict, ranging from violence against the government (civil war (1000 deaths) and civil conflict (25 deaths)) to low intensity conflict (e.g., protests and riots), inter-communal violence (conflict occurring between competing groups within a state), and land occupations. The justification for this broad definition of conflict is that the literature does not specify any standard violent reaction to climate-induced economic downturns and societies tend to experience multiple types of violence when economic conditions deteriorate.

[3] Climatic conditions could also affect the likelihood of conflict via a direct physiological channel, i.e., warmer temperatures by elevating levels of discomfort and aggressiveness increase interpersonal violence (e.g., [71, 83]) as well as via other indirect channels such as migration (e.g., [41, 66]).

less-developed countries, since these countries are heavily dependent on agriculture, are typically poor, politically unstable, and have a lower capacity for adaptation [31]. The theoretical literature provides several mechanisms which connect climate-driven adverse economic conditions and conflict. These include lower opportunity costs for participating in violence, weakened state capacities, and politico-economic inequalities and grievances [60]. Contrary to the overused statement that there is "strong causal evidence" that climatic events are linked to social conflict at all scales and across all major regions of the world ([59], 42),[4] the extant empirical literature does not provide robust evidence for a "direct" climate-economy-conflict connection, but rather shows that this relationship is scale and context dependent. It offers considerable suggestive evidence that economic conditions are an important link between climatic changes and conflict in countries and regions which are dependent on agriculture, host politically excluded groups, and have ineffective institutions. Future research should examine the specific mechanism(s) which link climate-driven economic downturns and conflict and specify the empirical analyses accordingly taking advantage of the availability of disaggregated data for the type of conflict,[5] climatic and economic conditions, and applying appropriate econometric methods.

Climate, the Economy, and Conflict: Theoretical Arguments

According to the neo-Malthusian framework, climatic conditions cause resource scarcity, which leads to competition and conflict [56]. Most of the existing literature theorizes that the effect of climate on conflict operates through economic conditions. The first step in this chain of causation emphasizes that adverse climate conditions, e.g., higher temperatures, lower precipitation rates, and extreme weather events, depress output [3, 18, 32, 58].[6] Shrinking incomes and diminished economic opportunities are subsequently theorized to cause conflict by adversely affecting local labor markets, since the value of engaging in conflict is likely to rise relative to the value of participating in normal economic activities ([24]; see also [44, 54]). That is, the *opportunity cost of rebellion* decreases because the expected returns from peaceful employment, e.g., farming, are lower than the expected returns from joining criminal or insurgent groups. In situations like these, when individuals expect to earn more from criminal- or insurgent-related activities than from lawful and peaceful ones, predatory behavior becomes more likely.

However, the negative effects of adverse climate conditions on economic output implies that the size of the appropriable "pie" is also lower, which reduces the incentives to fight in the first place [40, 43].[7] While the net impact of climate-driven economic downturns on conflict may be theoretically ambiguous [35], focusing on economic sectors which are disposed to experience climate-derived shocks may allow us to more precisely tease out an effect. Dal Bó and Dal Bó [29] model these opposing effects in a two-sector model of the economy and demonstrate that positive shocks (higher prices) to capital-intensive sectors (e.g., oil production) increase the value of controlling the state without increasing the opportunity costs of fighting, and hence increase the risk of conflict. In contrast, positive shocks to labor-intensive sectors (e.g., agriculture) increase the opportunity cost of fighting, and thus decrease the risk of conflict. Dube and Vargas [33] use data from 1000 Columbian municipalities and provide evidence in favor of these predictions. Their results demonstrate that a sharp fall in the international price of coffee substantially increased violence, such as guerilla and paramilitary attacks and clashes with government military forces, in coffee-producing municipalities. Their results also demonstrate that an increase in the international price of oil had a similar effect in municipalities with oil reserves and pipelines. They then use rural household surveys to show that the relationship between fallen coffee prices and violence operates through the labor market: the fall in coffee prices by disproportionately reducing the wages and work hours of rural workers in coffee-producing municipalities induced a lower opportunity cost of joining armed groups.

Climate-driven economic downturns are also likely to exacerbate actual or perceived economic and political *inequalities* in a society, which increase the likelihood of conflict by motivating individuals/groups to attempt to redistribute wealth and political power ([23]; see also [30, 47]). Moreover, recent research shows that higher inequality leads to riskier behavior in an attempt to achieve higher outcomes, in part, through social comparison processes [78].

Finally, another argument emphasizes *state capacity.* This argument posits that climatic changes by decreasing economic output reduce the amount of resources available to the state (e.g., reduced tax revenue), which curtails the government's ability to provide people with services and opportunities. It also limits the government's ability to suppress rebellion, thereby encouraging competitors to initiate conflict [17, 36].

[4] Hsiang and Burke [59] make this claim based on a meta-analysis of 50 studies (see also [19, 60]). Yet, their meta-analysis has been criticized with respect to sample selection, selection of indicators and interpretation of results [16].

[5] For example, the *Uppsala Conflict Data Program* Geo-referenced Event Dataset (UCDP GED), the Armed Conflict Location and Event Data (ACLED), and the Social Conflict Analysis Database (SCAD).

[6] See Carleton and Hsiang [21], Burke et al. [18], and Dell et al. [31] for recent reviews on the climate influences on various economic outcomes; and Arnell et al. [2] for a global assessment of the potential impacts of climate change across several sectors.

[7] Income volatility could also inhibit credible bargaining and commitments if it is associated with rapid shifts in power across groups [80].

Climate and the Economy: Empirical Evidence

The relationship between climatic conditions and the economy has been studied at the macro-level with aggregate economic variables, such as economic growth and income levels, and at more disaggregated levels with sectoral economic variables, such as agricultural income, industrial income, and agricultural yields and production rates.

Aggregate National Economy

The empirical evidence that climate affects aggregate economic activity is rather mixed [18]. Dell et al. [32], using a sample of 125 countries from 1950 to 2003, find that changes in precipitation do not have substantial effects on aggregate economic output in either poor or rich countries. However, they also report that higher temperatures reduce economic growth and overall levels of economic output in poor countries. They estimate that a 1 °C per annum temperature increase reduces economic growth by about 1.1 percentage points in poor countries. On the other hand, Burke et al. [18], using a global dataset of 166 countries from 1960 to 2010, find that higher temperature appears to affect GDP growth rates and GDP levels in poor and rich countries alike. They also report that temperature has non-linear effects on agricultural GDP and overall GDP in all countries, meaning that the association between growth and temperature is positive up to a certain point (i.e., 13 °C), before becoming negative. Barrios et al. [3], on the other hand, report that temperature has an insignificant effect on both the levels of GDP and economic growth in sub-Saharan countries [27]. They also find that rainfall decline has a significant negative effect on the economic growth of sub-Saharan countries, but not on non-African developing countries [92]. However, Barrios et al. employ weather anomalies, i.e., changes from country means normalized by country standard deviations, to operationalize precipitation and temperature. This operationalization is different from most other studies on the subject, which makes it possible that their empirical findings are due to their climate measurement variable.

Several other studies focus on extreme weather events, such as storms and droughts, and report similarly inconsistent results. Hsiang and Narita [61] examine the effects of tropical cyclones on 233 countries from 1950 to 2008. They find that cyclones cause substantial economic losses. However, Hsiang [57], using a study of 28 Caribbean countries, finds that cyclones have no average effect on income. He also reports that although some sectors experience significant negative impacts, e.g., agriculture and tourism, others experienced positive impacts, e.g., construction.

Agriculture

Most of the existing "sectoral" empirical work focuses on agricultural production due to its direct dependence on climate factors.[8] While there exists some evidence that developed countries suffer larger damage to agricultural production from extreme weather events, such as droughts and extreme heat waves, than developing countries [69], still the bulk of the existing literature focuses on developing countries because of their heavy dependence on agriculture and their lack of capacity to effectively offset adverse weather conditions [79]. Research shows that higher temperatures [18, 32], lower rainfall levels [3, 92], or extreme weather events [9] decrease agricultural output in developing countries. Recent research also shows that climate change could impact agricultural production and food security through 2030, particularly in sub-Saharan Africa and South Asia [52]. In addition, several other country and regional studies highlight the adverse effects of low precipitation and higher temperature on crop yields (e.g., wheat [96] and rice [25] in China; wheat in India [46]; cereal in West Africa [1]; rice in South Asia [70]) and agricultural production (e.g., tea production in Sri Lanka (Gunathilaka et al. [45] and cereal production in Ethiopia [34]).[9]

Climate-Driven Economy Downturns and Conflict: Empirical Evidence

Direct Relationship

Economic conditions have been singled out as a prime cause of conflict. The empirical literature provides substantial evidence that low income levels and poor economic performance are associated with conflict [93].[10] Given the evidence that adverse climate conditions lower economic activity, the vast majority of empirical studies focuses on the reduced form impact (i.e., direct relationship) of climate on conflict under the assumption that climate affects conflict mainly through its effect on a country's economy (Table 1). Most of this research, while accounting for a few contextual factors, such as economic development and differing political systems, provides little evidence for a strong, direct link between climate variability and conflict. While some studies do indicate a positive relationship between climate variability and conflict (e.g., [20, 39, 50, 68, 72, 82, 84]), other studies fail to find a significant relationship (e.g., [14, 76, 88]), or produce mixed evidence [27, 77].

For example, Burke et al. [20] report that higher temperature, measured by levels of average temperature, is significantly associated with civil war incidence in Africa during the 1981–2002 period. Buhaug [14], however, shows that Burke

[8] See Yohannes [97] for a review on the relationship between climate change and agriculture.

[9] Zhang et al. [98] argue that other climatic variables, especially humidity and wind speed, are also important for crop growth and their omission is likely to bias the effects of climatic changes on crop yields.

[10] See Blattman and Miguel [7] for a review of the conflict literature.

et al.'s result is not robust across alternative model specifications, and that climate variability, measured as inter-annual growth rates and deviations from annual mean precipitation and temperature, does not predict civil conflict. Several scholars note that other factors, e.g., population pressure, political regime, low economic development, and ethno-political exclusion, are likely to either condition this relationship [13, 42, 62] or to have a stronger impact on conflict risk than adverse climate conditions [10, 12, 76].

Indirect Relationship: Aggregate National Income

There are only a few quantitative studies which explicitly examine the causal pathways which link climate to violent conflict through economic conditions.[11] These studies primarily use rainfall and/or temperature as an instrument for economic conditions under the assumption that climate *only* influences conflict through the economy [26, 32, 67, 74, 75]. The results again do not reveal a strong relationship between climate, economic conditions, and conflict. Miguel et al. [75] use a dataset of 41 African countries from 1981 to 1999 and show that lower levels of rainfall growth reduce economic growth, which in turn increases the probability of civil conflict. They also report that this effect is not substantially dampened in countries with strong democratic institutions or lower levels of ethno-linguistic fractionalization (see also [55]).[12] Ciccone [26], however, claims that rainfall growth rates are not an appropriate measure of a rainfall shock due to the mean-reverting nature of rainfall, which makes rainfall shocks very transitory. He re-evaluates the Miguel et al. analysis after extending the time period to 2009 and replacing rainfall growth rates with overall rainfall levels, and finds that conflict is unrelated to rainfall. Miguel and Satyanath [74] attribute these contradictory results to the temporal difference between the two studies rather than to the change of the rainfall measurement. They also argue that the relationship between rainfall shocks and civil conflict appears to be weaker in Africa after 1999 because of Africa's unprecedented economic growth in non-agricultural sectors and, perhaps, the spread of democratization.

Koubi et al. [67] using a global dataset as well as an African sub-sample from 1980 to 2004 also do not find evidence that climatic variability, measured as deviations in temperature and precipitation from their 30 years long-run past levels (a 30 years moving average), increases the risk of civil conflict through a negative effect on economic growth (see also [92], and [6]). They also find than non-democratic countries are more likely to experience civil conflict when economic conditions deteriorate. This provides evidence that the effect of climate-driven economic downturns on conflict is conditional on the type of political system. Subsequent research shows that climate-related events, i.e., natural disasters and droughts, lead to conflict in non-democratic [27] and ethnically fractionalized and marginalized (e.g., [86, 95], and [27]) countries.

Indirect Relationship: Agricultural Production/Income and Food Prices

Agriculture is directly influenced by climatic conditions and consequently adverse weather conditions by reducing crop production and lowering agricultural income can lead to conflict.[13] The empirical literature largely confirms the relationship between adverse climate conditions, agricultural production, and conflict for individual countries, e.g., Indonesia [22], Philippines [28], India [8, 85], Colombia [33], and Brazil [53], and regions, e.g., Africa [48, 65, 90, 91] and Asia [91].[14] Caruso et al. [22] find that an increase in the minimum temperature during the core month of the rice growing season in Indonesia from 1993 to 2003 increased the number of violent incidents in heat-affected rural areas due to failed rice harvests. Similarly, Sarsons [85] shows that rainfall shortages in India led to Hindu-Muslim riots by lowering agricultural production and depressing local agricultural income. However, she finds that rainfall shortages and riots continue to occur together in districts with dams that supply irrigation, which should make agricultural production less sensitive to rain shocks. This suggests that agricultural income is unlikely to be the only pathway which links climate to conflict in this context.[15]

Several studies indeed show that the combination and interaction of climate-adverse economic conditions with social and political factors are critical to influencing conflict. For instance, Hidalgo et al. [53] show that negative economic shocks, instrumented by rainfall, increase the number of land invasions in Brazilian municipalities. They also show that highly unequal municipalities experience twice as many land invasions as municipalities with average land inequality. Von

[11] There also exist studies based on historic data showing that climate-driven economic downturns are associated with war in preindustrial Europe and the Northern Hemisphere [99], political instability in feudal Europe [89], the collapse of the Ming dynasty [100], and the peasant revolts in China over the 1470–1900 period [64].

[12] In one of the rare country studies, Bohlken and Sergenti [11], examine the outbreak of Hindu–Muslim riots in 15 Indian states between 1982 and 1995 and report that low economic growth (instrumented by annual changes in rainfall) increases the incidents of riots and that this result is driven primarily by the relationship between growth and riots within a state over time rather than across states.

[13] Maystadt and Ecker [73] focus on administrative regions in Somalia and report that droughts by decreasing livestock prices (a proxy for household income) increase the risk of violent conflict.

[14] Buhaug et al. [15] is the only study I reviewed that reports that although there exists a strong link between climate variability and agricultural output, still lower agricultural production is not associated with violent conflict in sub-Saharan Africa from 1960 to 2010.

[15] Sarsons [85] by presenting evidence of violation of the exclusion restriction casts serious doubt on the validity of rainfall and temperature as valid instruments for economic conditions.

Table 1 Overview of empirical studies on the climate-economy-conflict nexus

Author	Dependent variable	Independent variable(s)	Sample period	Sample region	Time unit	Spatial unit	Main results
Climate and conflict: direct effect							
Maystadt and Ecker [72]	Violent conflict events	Temperature	1997–2009	Sudan	Quarter	Pixel (0.5^0)	Yes
O'Loughlin et al. [76]	Violent conflict events	Rainfall and temperature	1980–2012	Sub-Saharan Africa	Month	Pixel (0.1^0)	Mixed/no
Landis [68]	Onset of civil war and non-state conflicts	Temperature	1979–2010	104 countries	Month	Country	Yes
Salehyan and Hendrix [84]	Conflict incidence	Drought, precipitation, and temperature	1970–2006	165 countries	Year	Country	Yes. Stronger effect in less developed and more agriculturally dependent societies
Couttenier and Soubeyran [27]	Civil war incidence	Palmer Drought Severity Index	1957–2005	38 sub-Saharan countries	Year	Country	Yes. In countries with a relatively large agricultural sector, low level of democracy, high ethnic and linguistic fractionalization
Fjelde and von Uexkull [39]	Communal conflict	Rainfall	1990–2008	Sub-Saharan Africa	Year	Province	Yes
Theisen et al. [88]	Civil war onset	Rainfall and drought	1960–2004	Africa	Year	Pixel (0.5^0)	No. Strong support for the exclusion (political marginalization) perspective
O'Loughlin et al. [77]	Civil war and social conflict	Temperature and precipitation anomalies	1990–2009	Horn and Eastern Africa	Month	Pixel (0.1^0)	Mixed
Raleigh and Kniveton [82]	Civil war and communal conflict events	Rainfall	1997–2009	Uganda, Kenya, and Ethiopia	Month	Conflict location	Yes/yes
Hendrix and Salehyan [50]	Civil conflict and social conflict	Rainfall	1979–2008	47 African countries	Year	Country	Yes
Buhaug [14]	Civil conflict	Precipitation and temperature	1979–2002	Sub-Saharan Africa	Year	Country	No. Stronger effect: low economic development and ethno-political exclusion have a stronger impact on conflict risk than climatic conditions
Burke et al. [20]	Civil war incidence	Precipitation and temperature	1981–2002	Africa	Year	Country	Yes
Climate, economy, and conflict							
van Weezel [92]	Conflict onset	Rainfall (IV for economic growth)	1981–2010	47 African countries	Year	Country	No
Hodler and Raschky [55]	Civil conflict incidence	Rainfall and Palmer Drought Severity Index (IV for intensity of nighttime lights: proxy for economic shocks)	1992–2010	53 African countries	Year	Regions	Yes

Table 1 (continued)

Author	Dependent variable	Independent variable(s)	Sample period	Sample region	Time unit	Spatial unit	Main results
Wischnath and Buhaug [95]	Civil conflict onset	Temperature and precipitation (IV for economic growth)	1950–2008	Asia	Year	Pixel (0.5^0)	No. Civil conflict risk is higher in localities with ethno-politically marginalized groups.
Koubi et al. [67]	Civil conflict onset	Precipitation and temperature from their past 30 years average (IV for economic growth)	1980–2004	Global and Africa	Year	Country	No. Non-democratic countries are more likely to experience civil conflict when economic conditions deteriorate
Bergholt and Lujala [6]	Civil conflict onset	Climatic disasters: flood/storms (IV for economic growth)	1980–2007	171 countries	Year	Country	No
Dell et al. [32]	Civil conflict and war; political instability	Temperature	1950–2003	Global	Year	Country	No/yes
Ciccone [26]	civil conflict onset or incidence	Annual rainfall levels (IV economic output)	1979–2009	41 African countries	Year	Country	No
Bohlken and Sergenti [11]	Ethnic riots	Rainfall (IV for economic growth)	1982–1995	India	Year	Province	Yes
Miguel et al. [75]	Civil war onset or incidence	Rainfall growth (IV for economic growth)	1981–1999	41 African countries	Year	Country	Yes
Climate, agriculture, and conflict							
Blakeslee and Fishman [8]	Crime incidence	Rainfall and temperature (IV for agricultural income)	1971–2000	India	Year	District	Yes
Jun [65]	Incidence of civil conflict	Maize growing season temperature (IV for agricultural yield)	1970–2012	37 sub-Sahara African countries	Year	Country	Yes
Von Uexkull et al. [91]	Civil conflict onset and incidence	Severity of growing-season drought for crops cultivated within a group settlement areas	1989–2014	Asia and Africa	Year	Pixel (0.5^0)	No/yes
Caruso et al. [22]	Number of violent incidents	Rainfall and temperature during the rice growing season and paddy rice production	1993–2003	Indonesia	Month	Province	Yes
Sarsons [85]	Ethnic riots	Rain (IV for agricultural income)	1970–1995	India	Year	Municipality	Yes. The effect of rainfall on conflict is stronger in areas downstream of dams even though irrigation makes agricultural production less sensitive to rain shocks
Buhaug et al. [15]	Violent conflict	Temperature and precipitation (IV for national food production)	1962–2009	Sub-Saharan Africa	Year	Country	No

Table 1 (continued)

Author	Dependent variable	Independent variable(s)	Sample period	Sample region	Time unit	Spatial unit	Main results
Crost et al. [28]	Number of conflict incidents	Rainfall (IV for agricultural production)	2001–2009	Philippines	Year	Province	Mixed
Von Uexkull [90]	Civil conflict incidence	Sustained drought and rainfed agriculture	1989–2008	Sub-Saharan Africa	Year	Pixel (0.5^0)	Yes
Harari and La Ferrara [48]	Incidence of conflict event	Drought shock during growing season	1960–2010	33 African countries	Year	Pixel (0.1^0)	Yes
Maystadt and Ecker [73]	Violent conflict	Temperature and drought length (IV for livestock prices)	1997–2009	Somalia	Month	Province	Yes
Dube and Vargas [33]	Incidents of guerrilla and paramilitary attacks	Coffee intensity (land used for cultivation) interacted with temperature and precipitation	1988–2005	Columbia	Year	Municipality	Yes
Hidalgo et al. [53]	Land invasions: dummy	Rainfall (IV for agricultural income measured by crop revenue)	1988–2004	Brazil	Year	Municipality	Yes. In highly unequal municipalities, negative income shocks cause twice as many land invasions as in municipalities with average land inequality
Climate, food prices, and conflict							
Bellemare [4]	Food related social unrest	Number of natural disasters (IV for food and cereal price indices)	1990–2011	Global	Month	Country	Yes
Raleigh et al. [81]	Violent conflict events	Rainfall/ drought and rainy season (IV for commodity price)	January 997–April 2010	24 African countries	Month	Administrative regions	Yes/yes
Smith [87]	Urban sociopolitical unrest	Rainfall (IV for domestic food price shocks)	1990–2012	48 African countries	Month	Country	Yes

Uexkull et al. [91] use geo-referenced conflict event data for Asia and Africa from 1989 to 2014 and find that local droughts increase the likelihood of sustained violence only in regions with agriculturally dependent and politically excluded groups.

Adverse climatic conditions are also likely to raise the price of food by reducing the supply of crops [38, 49, 94].[16] This can lead to various forms of social unrest, such as demonstrations and riots, e.g., the so called "food riots" [5]. It can also lead to civil conflict ([4, 81, 87]; see also [94]). Smith [87] reports a positive relationship between changes in domestic food prices and the outbreak of urban unrest in African countries. Similarly, Raleigh et al. [81] find that unusually dry weather increased the frequency of conflict in 113 African markets from January 1997 to April 2010 through its effect on food prices. Bellemare [4] exploits variations in natural disasters to identify a positive relationship between food prices and social unrest. He reports that higher food prices increased the incidence of riots from 1990 to 2011, while food price volatility did not result in a similar effect.

While this research provides evidence that climate-driven economic downturns can lead to conflict, it is still constrained to the extent that it focuses on specific countries, regions, and problems, such as failed harvests and increasing food prices. However, even in these cases, climate-induced agricultural production and food price shocks might not necessarily lead to conflict if they are well managed by capable governments. For instance, Fetzer [37] provides evidence that the introduction of a large-scale social insurance scheme in India—namely the National Rural Employment Guarantee Act (NREGA), which guarantees a hundred days of minimum-wage employment to every rural household—has weakened the relationship between monsoon rains and conflict by insulating agricultural wages and income from shocks. Hence, there is room for future work to build on these very promising studies and strive for a better specification (theoretically and empirically) of the conditions under which climate-induced economic shocks lead to conflict.

Conclusions and Future Research

Most of the studies reviewed in this article use modern econometric approaches and spatially disaggregated data which deal with the pervasive ecological fallacy problem which permeates the quantitative literature on climate and conflict research. However, these developments are not a panacea. Scholars must continue to pay attention to research design issues which enable the identification of causal effects. At the same time, these studies differ with respect to the conflict indicators used (e.g., civil conflict, riots, and land invasion), the characteristics of the employed conflict indicator (e.g., onset and incidence), the operationalization and/or measurement of the type of climate (e.g., monthly/yearly changes in precipitation/temperature, deviations from their long-term mean, and natural disasters) as well as of economic conditions (e.g., economic growth, levels of GDP, and agricultural output), and spatial (e.g., municipalities, countries or regions) and temporal (i.e., months, years) scales. Consequently, one could argue that while these differences account for important deviations in the statistical results, they also make it difficult to compare findings across studies and to draw general conclusions about the climate-economy-conflict relationship.

On the contrary, these studies show there is no robust evidence for a "direct" climate-economy-conflict connection. Instead, they provide considerable suggestive evidence that climate-driven economic downturns lead to conflict in agricultural dependent regions and in combination and interaction with other socioeconomic and political factors. More research needs to be done to clarify and understand the context(s) in which climate-driven economic downturns spur conflict. Future research also needs to identify and test the precise empirical implications of the various theoretical mechanisms, i.e., opportunity cost, inequality and grievance, and state capacity, which connect climate to the economy and subsequently to conflict. Only by understanding why conflict arises when economic conditions deteriorate due to climate, we will be able to design the appropriate policies and institutions to reduce conflict. In doing so, micro-level case studies along the lines of Dube and Vargas [33] may be a fruitful way forward.

[16] Hertel [51] argues that using food prices to assess climate impacts on food security is misleading and suggests that future research should use a broader indicator which encompasses other determinants of food security such as income as well as nutrition outcomes.

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